PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY
(Chapter II of the Patent Cooperation Treaty)

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION See Form PCT/IPEA/416	
14883PC RO		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/FI 2003/000059	24.01.2003	25.01.2002
International Patent Classification (IPC) or national classification and IPC		
C02F 1/465, C02F 1/463		
Applicant		
BCDE Group Waste Management LTD OY et al		

1. This report is the international preliminary examination report, established by this International Preliminary Examining Authority under Article 35 and transmitted to the applicant according to Article 36.
2. This REPORT consists of a total of 4 sheets, including this cover sheet.
3. This report is also accompanied by ANNEXES, comprising:
   a. ☒ *(sent to the applicant and to the International Bureau)* a total of 5 sheets, as follows:
      ☒ sheets of the description, claims and/or drawings which have been amended and are the basis of this report and/or sheets containing rectifications authorized by this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions).
      ☐ sheets which supersede earlier sheets, but which this Authority considers contain an amendment that goes beyond the disclosure in the international application as filed, as indicated in item 4 of Box No. I and the Supplemental Box.
   b. ☐ *(sent to the International Bureau only)* a total of (indicate type and number of electronic carrier(s))
      _____, containing a sequence listing and/or tables related thereto, in computer readable form only, as indicated in the Supplemental Box Relating to Sequence Listing (see Section 802 of the Administrative Instructions).
4. This report contains indications relating to the following items:
   - ☒ Box No. I Basis of the report
   - ☐ Box No. II Priority
   - ☐ Box No. III Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - ☐ Box No. IV Lack of unity of invention
   - ☒ Box No. V Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - ☐ Box No. VI Certain documents cited
   - ☐ Box No. VII Certain defects in the international application
   - ☐ Box No. VIII Certain observations on the international application

Date of submission of the demand	Date of completion of this report
08.08.2003	23.04.2004
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INTERNATIONAL PRELIMINARY REPORT ON PATENTABILITY

International application No.
PCT/FI2003/000059

Box No. I Basis of the report

1. With regard to the language, this report is based on the international application in the language in which it was filed, unless otherwise indicated under this item.

☐ This report is based on a translation from the original language into the following language english, which is the language of a translation furnished for the purposes of:

☒ international search (under Rules 12.3 and 23.1(b))
☐ publication of the international application (under Rule 12.4)
☐ international preliminary examination (under Rules 55.2 and/or 55.3)

2. With regard to the elements of the international application, this report is based on *(replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report):*

☐ the international application as originally filed/furnished

☒ the description:

pages 1-7,9-14 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* 8 received by this Authority on 18.08.03

☒ the claims:

pages _____ as originally filed/furnished
pages* _____ as amended (together with any statement) under Article 19
pages* 17-18 received by this Authority on 08.08.03
pages* 16, 15 received by this Authority on 041203,190404

☒ the drawings:

pages 1-2 as originally filed/furnished
pages* _____ received by this Authority on _____
pages* _____ received by this Authority on _____

☐ a sequence listing and/or any related table(s) – see Supplemental Box Relating to Sequence Listing.

3. ☐ The amendments have resulted in the cancellation of:

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, sheets/figs _____
☐ the sequence listing *(specify)*: _____
☐ any table(s) related to the sequence listing *(specify)*: _____

4. ☐ This report has been established as if (some of) the amendments annexed to this report and listed below had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2(c)).

☐ the description, pages _____
☐ the claims, Nos. _____
☐ the drawings, sheets/figs _____
☐ the sequence listing *(specify)*: _____
☐ any table(s) related to the sequence listing *(specify)*: _____

* *If item 4 applies, some or all of those sheets may be marked "superseded."*

Box No. V **Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Claims	1-11	YES
	Claims		NO
Inventive step (IS)	Claims	1-11	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-11	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

This report is based on the amended claims filed 08-08-2003 (page 17-18), 04-12-2003 (page 16) and 19-04-2003 (page 15).

Reference is made to the following documents, cited in the International Search Report:

D1: JP 10 258287 A
D2: S. Rubach et al, "Onshore testing of produced water by electroflocculation", Filtration & Separation, Oct 1997, pages 877-882.
D3: JP 81 32051 A
D4: JP 63 28081 A
D5: WO 94/14709 A1

D1 relates to a phosphoric acid removal device for sewage disposal systems, comprising tubular anode and cathode rods made of iron or aluminium and other insoluble metal. Iron and aluminium ions from the electrode facilitate removal of phosphoric acid from waste water (see figs. 3-8 and abstract).

D2 describes an electroflocculation unit for produced water and drainage water, consisting of an electrolytic cell with an aluminium anode and a stainless steel cathode. During the electrolysis, aluminium is released from the anode and hydrogen gas is formed at the cathode. It is noted in D1 that the separation efficiency is dependent on anodic wash, among other things.

D3 relates to a water purifier, comprising an electrolytic coagulator with an aluminium anode and a stainless steel cathode. Fig. 6b in D3 shows an embodiment with two coaxial

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Supplemental Box

In case the space in any of the preceding boxes is not sufficient.
Continuation of: Box V

pipe electrodes, the innermost being the cathode (31) and the outermost the anode (30).

D4 relates to an aggregating device for suspended matter that has a chemically stable cylindrical cathode and a cylindrical anode generating positively charged ions at electrolysis. The anode is placed on the inside and outside of the cathode (see abstract and fig. 1).

D5 describes an apparatus for electrolytic purification of polluted water, comprising an upright, cylindrical aluminium anode and a stainless steel cathode in form of a plate beneath the anode. D5 relates to the problem that the sacrificial surface of the anode becomes coated with impurities and oxidation products during electrolysis. The problem is solved by rotating the anode and applying liquid under pressure to flush the sacrificial surface clean (see abstract and fig. 3).

None of the cited documents discloses feeding of flush water under pressure through the innermost of two coaxial electrodes, for producing flush water sprays through holes in the innermost electrode against the inner surface of the outermost electrode, as claimed in amended claims 1 and 6.

Moreover, none of the cited documents disclose the automated cell current control claimed in claims 1 and 6.

No relevant combination of the prior art documents would lead a person skilled in the art towards the invention according to claims 1 and 6.

Thus, the invention according to claims 1 and 6, and claims dependent thereupon, is novel and considered to involve an inventive step. It is also considered to be industrially applicable.

- Biological denitrification as a nitrogen elimination method provides a nitrogen reduction of about 63% with comparatively expensive technology.
- Electrolysis has always provided a nitrogen reduction of more than 80%, and at best, e.g. in the treatment of cow dung, a nitrogen reduction of more than 99%, such that the nitrogen content of cleaned water is less than 2 mg/l.

The oxidation of iron to a ferric or ferrous ion and the reduction of nitrogen take place in a cell at a certain point of resonance energy. In other words, the electrical energy introduced into a cell must be dimensioned according to the dimensioning and flow of the cell, i.e. the retention time of waste water in the cell space. The search for a proper point in resonance energy must be conducted experimentally and then the cell current is controlled by automation with respect to the flow of waste water. The flow-through of waste water need not be intercepted for a washing period, since the washing is executed at a substantially higher pressure and with a smaller liquid volume than the pressure and liquid volume of through-flowing waste water.

3. TREATMENT OF LANDFILL SEEPAGE

An apparatus as shown in fig. 2 was used for conducting a series of tests in relation to the applicability of the apparatus for the cleaning of landfill seep water.

The following describes first a test apparatus, then a test procedure, and finally test results.

3.1 Test apparatus

A two-stage apparatus in the sense that two electrolytic cells 28 provided with aluminium electrodes (or two iron electrodes or one iron

pole of a power source and one or more metal electrodes (1) coupled with the negative pole of a power source, and an electrolysis space (5) between the electrodes, the electrode (1) connected to the negative pole of a power source being made at least in its surface layer from a more electronegative material than the electrode (2) connected to the positive pole, the more electronegative electrode (1) being non-wearing in a cleaning process and releasing only electrons received thereby into a solution to be cleaned, and the less electronegative electrode being an active, wearing electrode in a cleaning process and releasing metal ions into a solution to be cleaned, the electrodes (1, 2) having such an electronegativity difference that a desired oxidation-reduction reaction is achieved, **characterized** by the combination of

- automation for controlling the cell current at the point of cell's resonance energy, thereby enabling a desired oxidation-reduction reaction in the cell in a strictly controlled electric field
- a separation tower (30) of a flock and purified water
- a pump (27) for pumping a mass flow through the cell (28), as a closed continuous flow, to the separation tower (30)
- coaxial pipes as the electrodes (1, 2), the inner electrode pipe being the more electronegative electrode (1) and having holes (4), and
- flushing means (16-20) for feeding flush water intermittently through the inner electrode pipe by pressure for producing flush water sprays through the holes (4) against inner surface of the outer electrode pipe (2).

7. An apparatus as set forth in claim 6, **characterized** in that the less electronegative electrode is made of iron or aluminium, the iron or aluminium pipe (2) being the outermost and readily replaceable.

8. An apparatus as set forth in claim 7, **characterized** in that the outer electrode pipe (2) terminates prior to a waste water inlet (6), while the inner

pipe (1) continues past the waste water inlet (6) by way of a valve (18) to a wash water pump (19).

9. An apparatus as set forth in claim 8, **characterized** in that the valve (18) has its opening and the wash water pump (19) has its actuation controlled to proceed intermittently, while a valve (17) in an outlet duct (16) connected to the bottom end of the electrolysis space (5) is adapted to be opened for discharging precipitate and wash water from the electrolysis space (5).

10. An apparatus as set forth in any of claims 7-9, **characterized** in that the inner electrode pipe (1) is made of stainless steel and the iron- or aluminium-made outer electrode pipe (2) is covered with an insulating housing tube (3).

11. An apparatus as set forth in any of claims 7-10, **characterized** in that the electrode pipes (1, 2) are locked concentrically to each other by means of unscrewable end caps (10, 15), which surround the ends of the inner electrode pipe (1) and inside which are retained the ends of the outer electrode pipe (2).

b) the precipitate is allowed to rise along with hydrogen gas in the form of flock to the surface of clean water in the flock separation tower (30); and

c) in electrolysis, iron is oxidized and NH_4^+ nitrogen and/or nitrate nitrogen (NO_3) is reduced as follows

$$Fe + NH_4^+ + OH^- \Leftrightarrow FeO \downarrow + 2\frac{1}{2}H_2 \uparrow + \frac{1}{2}N_2 \uparrow$$

and/or

$$6Fe + 2H^+ + 2NO_3^- \Leftrightarrow 6FeO \downarrow + N_2 \uparrow + H2 \uparrow$$

whereby the result is denitrification as nitrogen escapes from waste water in the form of nitrogen gas.

3. A method according to claim 1, where the waste water is landfill seepage or some other salt-containing waste water, such as contaminated sea water.

4. A method according to claim 3, **characterized** in that the seepage or other salt-containing waste water to be cleaned is conducted in a first stage through a first electrolytic cell, and in a second stage the water partially cleaned in the first stage is conducted through a second electrolytic cell.

5. A method as set forth in any of claims 1-4, **characterized** in that the less electronegative electrode is made of iron or aluminium.

6. An apparatus for removing impurities from waste water by electroflotation, said apparatus comprising a set of electrolytic cells, each cell thereof being provided with one or more metal electrodes (2) coupled with the positive

Claims

1. A method for removing impurities from waste water by electroflotation, the method comprising the steps of

- passing the waste water to be cleaned through an electrolytic cell (28) provided with two metal electrodes (1, 2) of different electronegativities
- performing electrolysis between the two electrodes (1, 2), such that the more electronegative electrode (1), which is non-wearing in a cleaning process, is used for producing hydrogen gas and hydroxyl ions from water, and that the less electronegative electrode (2), which is an active, wearing electrode in a cleaning process, is used for producing metal ions in a solution to be cleaned, **characterized** in that the method further comprises the combination of following steps:
- controlling the cell current by automation at the point of cell's resonance energy to produce a strictly controlled electric field in the cell
- effecting in the cell in the strictly controlled electric field a desired oxidation-reduction reaction for removing one or more designated impurities from water to be cleaned
- feeding the mass flow from the cell to a separation tower (30) of a flock and purified water
- using coaxial pipes as electrodes, the inner electrode pipe being the more electronegative electrode (1), having holes, and
- feeding flush water intermittently through the inner electrode pipe by pressure for producing flush water sprays through the holes against inner surface of the outer electrode pipe.

2. A method as set forth in claim 1 for removing nitrogen from waste water, **characterized** in that

a) in electrolysis, hydrogen ions (H^+) are used for producing from ammonia (NH_3) ammonium ions (NH_4^+), which escape upon joining negative ions and upon coprecipitating with iron hydroxide precipitate;